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AN IGNITION SYSTEM FOR CONSUMABLE CASE AMMUNITION

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27 MAY 1957



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AN IGNITION SYSTEM FOR CONSUMABLE CASE AMMUNITION

Prepared by:

Edwin F. Abrams
Eugene E. Elzufon
Raymond Harwell

ABSTRACT: Three methods of igniting consumable case ammunition were studied:

1. A primer fabricated from consumable material located in the normal position at the rear of the cartridge case.
2. A primer located in the base of the projectile contacted by a firing pin through the side wall of the barrel.
3. A projectile primer fired through a capacitor coupling which eliminates the need for a firing pin.

Firing results for all three methods are presented along with illustrations and methods of fabrication.

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AN IGNITION SYSTEM FOR CONSUMABLE CASE AMMUNITION

Prepared by:

Edwin F. Abrams, Eugene E. Elzufon and Raymond Harwell

ABSTRACT: Three methods of igniting consumable case ammunition in a 30mm weapon have been studied with the following results:

a. The first approach was an electric primer constructed from fully combustible components molded into the base of the round. These primers have been used in assembled rounds giving satisfactory ballistics in the test weapon at both ambient temperatures and -65°F. The primers have successfully withstood high temperature storage, severe aircraft vibration, and 40 foot drop testing with no serious deformation of the primer or its components. Test firings have been conducted in 30mm and 37mm guns at the Armour Research Foundation, with rounds assembled using this primer.

b. The second approach uses a N-36 20mm primer mounted in the base of the projectile. The firing circuit goes from a spring loaded firing pin in the side of the gun barrel to the primer through a contact ring mounted behind the rotating band on the projectile. These primers have been used to fire T-241 projectiles at -65°F, +90°F and +160°F with full charge consumable rounds yielding gun pressures up to 70,000 psi, with no apparent damage to primer, projectile or firing pin assembly. These primers have successfully withstood rough handling and temperature and humidity storage testing.

c. The third approach uses capacitor coupling influence firing having one plate of the condenser in the gun barrel and the other in the projectile. This system has not been tested in a gun to date. However, tests with a mock-up round and gun barrel indicate this method is feasible. Some obvious advantages to this system are: (1) elimination of firing pin contact difficulties where there is no cartridge case to aid in obturation; and (2) availability of a reliable electric primer ignition system which is insensitive to "inductive" influence firing from "radar" transmitters.

It is concluded that all three methods studied for igniting consumable case ammunition are feasible and warrant further study.

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The work reported herein was begun under Task NOL-Re2a-329 and completed under Task NO-182-816/64011/02040 as requested by the Bureau of Ordnance, to investigate methods of igniting completely consumable aircraft machine gun cartridge ammunition.

This work is the result of the joint efforts of the Non-Metallic Materials Division (WM), of the Chemistry Research Department, and the Electromagnetics Division (RM), of the Physics Research Department. The results and conclusions represent the best opinion of the Laboratory on the feasibility of igniting consumable case ammunition and may be used as a basis for action.

W. W. WILBOURNE
Captain, USN
Commander

Albert Lightbody
ALBERT LIGHTBODY
By direction

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Acknowledgment

The authors gratefully acknowledge the contributions of Dr. Harold Anderson and Mr. Roscoe Dwigins, whose original ideas aided in the performance of the work presented in this report.

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- Reference (a) - Development of a Series of Metal-Oxidant Igniter Materials for use in Rocket Igniters and Gun Primers, H. Hurwitz, E. E. Elzufon, L. F. X. Cowen, JANAF Second Symposium on Solid Propellant Ignition, Volume I, October 2, 3, 4, 1956.
- Reference (b) - Development of a 30mm Automatic Gun For Use With Combustible Case Ammunition, Report No. 11, Armour Research Foundation, Figure 2.
- Reference (c) - Improved Initiators for Rocket Igniters, G. W. Peet, H. Hurwitz, E. E. Elzufon, JANAF Second Symposium on Solid Propellant Ignition, Volume II, October 2, 3, 4, 1956.

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INTRODUCTION

1. The Naval Ordnance Laboratory was requested by the Bureau of Ordnance to develop an electrically initiated ignition system for consumable cartridge case ammunition being used in a high performance 30mm aircraft gun. This ignition system was required to: (1) ignite the propellant satisfactorily and (2) leave no residue from either primer or cartridge case after firing. This would eliminate the necessity of ejecting the spent primer and cartridge assembly, thereby allowing a higher rate of fire. In the course of this work the Laboratory investigated the three types of ignition systems listed below:

a. Consumable Primer. This primer, which is fabricated from consumable material, is located in the normal position at the base of the cartridge case, and is intended to be entirely consumed after the shot.

b. Projectile Primer. This system employs a standard primer located in the base of the projectile. The primer fires back into the propellant bed and is carried out of the gun with the projectile.

c. Primer Fired by Capacitor Coupling Influence System. This system uses the projectile primer but substitutes a capacitor coupling for the firing pin. The contact band on the projectile is concentric with an insulated band in the gun chamber, thus forming a condenser. A high frequency firing pulse is delivered through this condenser to the primer.

COMBUSTIBLE PRIMER

2. The experimental combustible primers (designated XG-63A and B - see Figure 1) are composed of two major sections; the base and the extension tube. These two sections are molded from an experimental primer composition consisting of NH_4ClO_4 and epoxy resin, designated XC-12A (see Appendix A). These primers are fabricated at the Laboratory in the following manner:

a. The bases and the extension tubes are molded at 325°F under a pressure of about 3500 psi.

b. Lead holes are drilled in the base.

c. Soft solder leads are installed and the conductive lacquer is brushed on.

d. A .002 inch diameter Pt-Ir bridgewire is soldered in place.

e. The primary composition is buttered in the bridgewire cavity and oven dried. The primary composition consists of 98% n-lead styphnate and 2% nitrocellulose in an excess of n-butyl acetate.

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f. The extension tube is filled with approximately 0.3 gm of a boron, zirconium, $KClO_4$ igniter composition designated XG-9B1 (see Appendix B and Reference (a)).

g. The loaded extension tube is then bonded to the base using the binder epoxy resin as the adhesive.

The purpose of the conductive lacquer is to provide a means of delivering electrical energy to the primer. In the case of the XG-63A, the bullseye is contacted by the firing pin and ground contact is made through the outer ring. In the XG-63B the entire base of the primer can be used for firing pin contact while ground contact is made through a fine wire leading out the forward end of the extension tube (see Figure 1).

3. The XG-63A primers were tested in a 30mm single shot test barrel with reduced propellant charges. In these tests the propellant was IMR 5010, a .50 caliber propellant, and the cartridge case was a cardboard tube. Initial firings (Table I) were made to compare the effect of the primer booster charge on ejection times. Long ignition delays were encountered with FFFG black powder, pistol powder and a coarse (10/12 mesh) granulation of the XG-9B1 experimental metal-oxidant composition. Satisfactory ignition times were obtained when the 16/20 mesh granulation of XG-9B1 was used.

4. More extensive firings were conducted with XG-63A primed rounds at room temperature and -65°F. In these rounds all the primers contained 16/20 mesh XG-9B1, the cartridge cases were cardboard tubing and the propellant was IMR 5010 at a loading density of 0.72 gm/cc (see Table II). Pressures were recorded in the center of chamber using an expanding ferrule type pressure gauge. Ejection times were obtained by using a break-wire timer stop circuit having the projectile break a fine wire as it left the muzzle. A schematic diagram of the barrel, projectile trap, and timing system is shown in Figure 2. Muzzle velocities were not obtained on the majority of these firings because of instrumentation difficulties accompanying the use of photocell type velocity screens. The printed circuit timer stop, shown in Figure 2, was employed at a later date and was used in taking the data in the test firing of completely consumable rounds mentioned later in this paper.

5. Several XG-63A primers were sent to the Armour Research Foundation at Joliet Arsenal, for test firing in a 37mm completely consumable round. Ignition was obtained in all firings with no evidence of any residue from the primers. However, long ignition delays were recorded. It is felt that these delays could be eliminated by increasing the quantity of booster charge in the primers to better ignite the larger 37mm propellant grains.

6. A number of XG-63B primers (see Figure 1), were made and sent to the Armour Research Foundation in Chicago, Illinois, for tests in a high performance 30mm aircraft machine gun to be used with totally consumable rounds. The modified ground contact was designed in this primer

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to comply with the unusual design of the round developed by ARF where the projectile is enveloped by the cartridge case (reference (b)). The forward ground lead is connected directly to the base of the projectile and the entire primer base is a single contact surface. Several rounds were fired in Armour's single shot test barrel and ignition was obtained with no residue but long ignition delays were encountered.

7. These combustible primers were subjected to aircraft vibration, jolt and 40 foot drop tests with no noticeable damage. These tests did not affect the primer actuation time.

PROJECTILE PRIMER

8. The projectile mounted primer, designated XG-64B, consists of an adapter on the base of the projectile containing a 20mm rivet type primer (see Figure 3). Contact is made through an insulated ring around the adapter and a spring to the side wall of the primer. Ground contact is made from the primer electrode through the projectile. The firing pin is located in the barrel wall (see Figure 4).

9. Development of a suitable firing pin for this primer proved to be a considerable task. This is so because the firing pin is not obturated from the hot combustion gases as it is with a standard brass cartridge cased round. However, with the design illustrated in Figure 5, as many as thirty consecutive rounds at pressures up to 50,000 psi were fired without any noticeable damage to the firing pin assembly. The major problem is to keep the hot gases away from the insulator between the electrode and the grounded stock. Since no automatic weapon was in existence to test this firing pin design, no concrete conclusions can be drawn as to its effectiveness under rapid fire conditions.

10. Preliminary firings with the projectile primer were made in reduced charge rounds with cardboard cases at room temperatures and -65°F. This data appears in Table III. IMR 5010 propellant was used in all shots. Shots 1 through 23 were fired using the primer XG-64A which differs from the XG-64B shown in Figure 3 in that it does not have the retaining sleeve to support the sides of the 20mm primer. The ignition delays appearing in this series of shots were caused by the rupturing of the side wall of the primer thereby venting some of the ignition charge through the contact spring hole instead of directing the full charge into the propellant. When the XG-64B with a retaining sleeve was used (in shots 24-31) all evidence of any misfires or long ignition delays disappeared.

11. The first series of completely consumable rounds (shots 52-55) were fired in the same barrel as those with cardboard cases using the projectile primer XG-64B (see Table IV). These were fired with reduced charges because the combustible case material used (all case material was supplied by the Armour Research Foundation) was of an early ethyl cellulose formulation, known to be very porous and apt to give high pressure peaks. Shots 52 and 53 used IMR 5010 propellant and shots 54

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and 55 used 40mm SPDN propellant. The shots did show high peak pressures for the low loading densities used.

12. The next series of completely combustible rounds were assembled with a less porous VYHH formulation (polyvinylchloride-acetate copolymer) material and fired in a heavier barrel at full charge with the XG-64B projectile primers. These were fired at room temperature, 160°F and -65°F. The data for this series of shots are listed in Table V. The muzzle velocities obtained in this series of shots used the printed circuit timer stop. When the projectile enters the sand trap it passes through the printed circuit paper thereby breaking a circuit to stop the electronic chronograph.

13. The XG-64B primers were subjected to aircraft vibration and 40 foot drop tests with no noticeable damage.

14. The projectile primer has several distinct advantages over the combustible primer:

- a. Much easier to manufacture.
- b. Easier to waterproof round.
- c. The firing pin on the side of the barrel will be wiped clean by the entering of each succeeding round.

CAPACITOR COUPLING INFLUENCE SYSTEM

15. The development of a suitable primer for consumable case ammunition and the firing pin problem encountered in doing so, led the Laboratory to investigate the feasibility of an influence method of ignition, in order to eliminate the need for a direct electrical contact to the primer. The system used transmits electrical energy to the primer through a capacitor formed by two concentric rings, one on the projectile and one in the barrel.

16. A circuit was designed (see Figure 6) to test various types of electrical initiators. The circuit consists of a high frequency power source, a capacitor to ground (C_1) with a coil in parallel with it, another capacitor (C_2) leading to the primer, and the primer itself leading to ground. The fixture used to test the various primers is shown in Figure 7. It can be seen that the capacitor to ground (C_1) is comprised of the insulated ring in the barrel as one plate and the barrel itself as the other plate. Sending power through this capacitor would be wasteful, so the parallel inductance is used to tune this stray capacitance to antiresonance to increase the shunt impedance. A similar inductance could be introduced in series between the capacitor to the primer (C_2) and the primer to reduce the impedance of that path. (The plates of C_2 are the insulated ring in the barrel and the insulated ring on the projectile.) Measurements have shown C_2 to vary from about 100

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micromicrofarads if the projectile is centered to as high as 0.1 microfarad if the bands are almost touching. Tests have shown that a series inductance here is not necessary if the power frequency is above one megacycle. The ring on the projectile, having the same O.D. as the rifling band, is made of the same material as the rifling band so as not to harm the bore of the gun when the round is fired. The O.D. of the contact ring on the projectile is such that separation between the plates of C_2 is small, thereby making its capacity as high as possible. One side of the primer is connected to the contact ring on the projectile and the other side to ground through the projectile.

17. Initial tests were conducted with conductive mix type 20mm primers loaded with FA-878 (Appendix C) using power source frequencies of both one and fifty megacycles at approximately 50 V. AC. Audible ignition delays were encountered. It is felt that a marginal amount of energy was delivered to the primers. Conductance of these primers increases rapidly with increase of temperature or current. The resistance decreased from several thousand ohms at low current to less than one ohm at initiation. In order to decrease the delay time of these primers, the voltage of the power supply was increased so as to supply approximately 90 volts AC at 2.8 megacycles to the primers. The samples tested (see Table VI) had delay times less than 0.75 millisecond.

18. Assuming that matching power output impedance, coaxial cable characteristic impedance, and primer impedance is critical at high frequencies, attention was directed to the testing of bridgewire initiators having a constant impedance. The initiators selected were a standard squib (Mk 1) with a resistance of approximately 1.1 ohms and an experimental squib (XE-8A, reference (c)) having a resistance range of 15-20 ohms. These resistance values were found to change less than 5% when the bridgewires were heated. Table VII lists the squib actuation times obtained using a power source frequency of 1.6 megacycles and 90 V. AC. From the times obtained, ranging from 0.22 to 0.57 millisecond for the Mk 1 squib and 0.25 to 0.42 millisecond for the XE-8A squib, it is felt that this method of introducing power to a bridgewire initiator is very feasible.

19. A disadvantage of using a high frequency power source in aircraft gun application is the size of the power output unit. It would have to be placed at a distance from the gun, possibly requiring as much as 50 feet of coaxial cable for connection. At low frequencies, this would appear as a large capacitance in parallel with C_2 . (see Figure 6) and at high frequencies, standing waves might occur in the cable.

20. A simpler, more compact, power source was devised which does not employ high frequencies. The circuit diagram appears in Figure 8. Operation of the circuit is explained as follows: If C_3 is charged when switch S is closed, C_3 discharges and L_2 and C_2 are then charged. L_2 and C_2 immediately discharge through the primer and a damped oscillation of several cycles duration results. The actual duration depends upon

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both the time constant of the circuit and the series resistance; a large time constant tending to increase the duration and a large resistance causing early damping. The $L_1 - C_1$ combination is tuned so as to make its impedance very high. Its resonance frequency is 0.5 megacycles. Several charging voltages were tried and it was found that a minimum of 990 V. DC was required for reliable firing. Firing times for Mk 1 squibs using this system (averaging 0.18 milliseconds) appear in Table VIII.

CONCLUSIONS AND RECOMMENDATIONS

21. The combustible primer XG-63A, gave good ignition with the IMR 5010 propellant in tests at the Laboratory. The primer left no residue in tests at the Laboratory and at the Armour Research Foundation. It is concluded that further development of this primer would lead to satisfactory ignition with larger grain propellant used in other existing consumable rounds.

22. The projectile primer XG-64B, gave good ignition with all rounds tested at room temperature, 160°F and -65°F. It is felt that this type of ignition system could be used successfully on larger caliber consumable rounds as well as with high performance small caliber guns.

23. The capacitor coupling influence system using both high frequency power supplies and condenser discharge pulse, shown to be feasible for supplying electrical energy to initiators, is foreseen to have numerous applications. It is a unique method of accomplishing ignition without the aid of direct contacts. Listed below are some possible applications for the influence system:

- a. Ignition of consumable case ammunition
- b. Ignition of hermetically sealed items
- c. Ignition of plastic cased rounds
- d. Ignition of non-conductive coated metallic cased rounds
- e. Ignition of gun fired rockets

For the application relating to the ignition of consumable case ammunition it is felt that the next logical step would be to engineer an actual gun chamber and corresponding round for further testing of the influence system.

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APPENDIX A

Experimental Primer Composition, IC-12A

78.4% NH_4ClO_4	Reagent Grade on 70 mesh	39.0%
	on 120 mesh	29.7%
	on 200 mesh	15.0%
	on 325 mesh	8.9%
	thru 325 mesh	7.4%

21.6% Araldite CN-502 "Epoxy" Resin	(Manufactured by
with HN-95 Hardener (Amine)	Ciba Co., Inc.)

APPENDIX B

Experimental Igniter Composition, XG-9B1

47.3% KClO_4	Reagent Grade	100% thru 200 mesh
		75% thru 325 mesh

47.3% Zirconium Granular	100 mesh to 10 microns
	(Manufactured by Foote Mineral Co., Exton, Pa.)

2.4% Epoxy Resin HR-18795	(Manufactured by Bakelite Co.,
and HR-18793 (4:1)	Bound Brook, N. J.)

APPENDIX C

FA-878 Igniter Composition

Manufactured in accordance with U. S. Army Ordnance Manual P-1, Primer, Pyrotechnic, and Incendiary Compositions for Small Arms Ammunition

$\text{Ba}(\text{NO}_3)_2$	20%
PbO_2	20%
Zirconium (Granular)	32.5%
Zirconium (Powdered)	7.5%
PETN Grade B	20.0%

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TABLE I
PRELIMINARY COMBUSTIBLE PRIMED SHOTS (REDUCED CHARGE)*

Shot No.	Primer Booster Charge	Propellant Loading Density (gms/cc)	Time to Start of Pressure Rise (ms)	Time to Peak Pressure (ms)	Peak Pressure (psi)	Muzzle Velocity (ft/sec)
2	FFFG Bl.P.	0.67	7.7	9.0	32,357	1704
3	FFFG Bl.P.	0.80	8.3	9.6	41,148	1923
5	XG9B1 16/20	0.71	1.2	2.7	35,860	-
9	Pistol Powder	0.72	Long delay		-	2050
10	XG9B1 10/12	0.72	Long delay		-	2110

* Fired with 4 yfd. and 250 V.

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TABLE II
XG-63A REDUCED CHARGE FIRINGS*
0.72 gms/cc PROPELLANT LOADING DENSITY

Shot No.	Temp.	Time to Start of Pressure Rise (ms)	Time to Peak Pressure (ms)	Peak Pressure (psi)	Ejection Time (ms)
32	Room	1.0	2.0	44,700	4.44
33	"	2.8	4.0	44,700	6.46
34	"	1.1	2.1	43,300	5.00
35	"	1.0	2.0	45,200	4.90
36	"	film exposed			5.04
37	"	0.8	1.8	45,300	4.40
38	"	2.0	3.0	38,400	5.80
39	"	1.2	2.3	film exposed	
40	"	1.0	2.0	38,000	4.67
41	"	pressure gauge failed			4.60
42	"	0.5	1.2	32,800	4.15
43	"	1.3	2.1	34,400	4.96
44	"	1.3	2.2	35,350	5.00
45	"	0.9	1.7	35,850	4.33
46	"	1.3	2.2	34,550	5.02
47	-65°F	3.5	4.5	31,000	7.80
48	-65°F	2.1	3.0	30,350	6.37
49	-65°F	3.0	4.1	31,000	7.30
50	-65°F	0.6	1.3	32,000	4.40
51	-65°F	0.7	1.6	33,000	4.74

* Fired with 4 yfd and 250 V.

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TABLE III

PROJECTILE PRIMER ROUND SHOTS (REDUCED CHARGE)*
PROPELLANT LOADING DENSITY OF 0.67 gms/cc

Shot No.	Temp.	Primer	Time to Start of Pressure Rise (ms)	Time to Peak Pressure (ms)	Peak Pressure (psi)	Muzzle Velocity (ft/sec)
1	Room	XG-64A	0.5	2.1	34,560	-
4	"	"	0.8	2.2	32,734	-
6	"	"	3.0	4.8	34,300	-
7	"	"	2.0	3.5	30,800	1887
8	"	"	long delay - no trace			2190
12	"	"	long delay - no trace			1942
13	"	"	2.3	3.7	39,400	1961
14	"	"	long delay - no trace			1961
15	"	"	long delay - no trace			-
16	"	"	long delay - no trace			1935
17	"	"	1.0	2.0	42,300	-
18	"	"	1.0	1.6	40,100	1930
19	-65°F	"	4.3	5.2	34,800	1961
20	-65°F	"	Primer did not fire - circuit not complete			
21	-65°F	"	15.5	16.4	37,000	1840
22	-65°F	"	Misfired - did not ignite propellant			
23	-65°F	"	6.0	6.9	33,500	1807
24	Room	XG-64B	1.0	1.5	36,600	1948
25	"	"	0.9	1.5	36,500	-
26	"	"	1.0	1.8	38,750	-
27	"	"	1.0	1.8	37,300	-
28	"	"	1.0	1.8	38,300	-
29	-65°F	"	1.1	2.0	33,300	-
30	-65°F	"	3.0	4.0	32,600	-
31	-65°F	"	1.1	2.0	32,800	-

* Fired with 4 yfd and 250 V.

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TABLE IV
COMPLETELY CONSUMABLE BOUND SHOTS (REDUCED CHARGE)*

Shot No.	Primer	Propellant Charge (gms)	Weight of Case (gms)	Propel. Loading Density (gm/cc)	Time to Start of Pres. Rise (ms)	Time to Peak Pres. (ms)	Peak Pressure (psi)	Ejection Time (ms)
52	XC-64B	10**	16.9	0.57	0.2	0.6	45,600	4.18
53	XC-64B	9.9**	17.0	0.57	0.3	0.9	47,000	4.19
54	XC-64B	14***	16.4	0.64	0.3	0.7	50,800	4.15
55	XC-64B	11***	15.9	0.57	0.4	0.9	43,000	4.52

* Fired with 4 yfd and 250 V.

** .50 Cal DMR Propellant

*** 40mm Propellant SPDN 7195

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TABLE V
COMPLETELY CONSUMABLE ROUND SHOTS (FULL CHARGE)
ALL SHOTS USED XC-64B PROJECTILE PRIMER*

Shot No.	Temp.	Propellant (gms)	Case (gms)	Propel. Loading Density (gm/cc)	Time to Peak Pres. (ms)	Peak Pressure (psi)	Time to Ejection (ms)	Muzzle Velocity (ft/sec)
56	Room	50.2	20.3	0.60	2.3	36,500	4.47	-
57	"	62.2	20.4	0.70	2.4	44,450	4.10	-
58	"	71.8	20.3	0.78	2.0	49,250	3.75	-
59	"	71.6	20.5	0.78	1.7	51,800	3.55	-
60	"	71.7	20.4	0.78	1.9	55,000	3.85	3366
61	"	72.0	20.1	0.78	2.0	58,950	-	-
62	"	71.6	20.5	0.78	2.0	63,365	3.35	2695
63	"	71.5	20.6	0.78	2.0	-	3.44	-
64	"	71.8	20.2	0.78	1.9	-	3.51	3550
65	"	72.1	20.0	0.78	2.4	65,980	4.32	3515
66	160°F	71.9	20.2	0.78	1.9	70,585	-	3603
67	160°F	72.0	20.1	0.78	1.6	70,290	-	-
68	160°F	72.0	20.1	0.78	1.4	64,635	-	-
69	160°F	71.9	20.2	0.78	1.6	68,970	3.41	3013
70	-65°F	72.0	20.1	0.78	-	-	4.55	3350
71	-65°F	72.0	20.1	0.78	-	-	4.17	-
72	-65°F	71.9	20.2	0.78	3.4	58,430	5.35	-
73	-65°F	72.6	19.5	0.78	3.4	60,170	5.23	3414
74	-65°F	71.3	20.8	0.78	3.2	58,940	5.02	-
75	-65°F	71.3	20.8	0.78	8.4	57,645	9.72	2845

* Fired with 4 yfd and 250 V.

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TABLE VI

FUNCTIONING TIMES OF 20MM CONDUCTIVE MIX PRIMERS
FIRED WITH CAPACITOR COUPLING INFLUENCE SYSTEM
USING A 2.8 MEGACYCLE POWER SOURCE AT 90 V.

<u>Shot No.</u>	<u>Functioning Time (ms)</u>
1	0.74
2	0.52
3	0.59
4	0.54
5	0.54
<hr/>	
Average	0.59 ms.

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TABLE VII

FUNCTIONING TIMES OF SQUIBS FIRED WITH CAPACITOR COUPLING
INFLUENCE SYSTEM USING A 1.6 MEGACYCLE POWER SOURCE
(90 V. AC)

Shot No.	Mk 1 Functioning Times (ms)	Shot No.	XE-8A Functioning Times (ms)
1	0.29	28	0.41
2	0.57	29	0.41
3	0.38	30	0.39
4	0.31	31	0.39
5	0.31	32	0.41
6	0.26	33	0.40
7	0.34	34	0.25
8	0.33	35	0.39
9	0.47	36	0.39
10	0.31	37	0.40
11	0.48	38	0.38
12	0.22	39	0.40
13	0.23	40	0.33
14	0.29	41	0.40
15	0.30	42	0.40
16	0.32	43	0.39
17	0.29	44	0.34
18	0.28	45	0.31
19	0.32	46	0.39
20	0.31	47	0.34
21	0.22	48	0.39
22	0.32	49	0.36
23	0.32	50	0.38
24	0.41	51	0.40
25	0.29	52	0.33
26	0.42	53	0.40
27	0.26		
Average	0.32	Average	0.37

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TABLE VIII

FUNCTIONING TIMES OF MK 1 SQUIBS FIRED WITH CAPACITOR
COUPLING INFLUENCE SYSTEM USING A CONDENSER DISCHARGE
PULSER (990 V., .01 yfd)

Shot No.	Functioning Time (ms)	Shot No.	Functioning Time (ms)
1	0.10	15	0.13
2	0.22	16	0.22
3	0.11	17	0.28
4	0.13	18	0.16
5	0.24	19	0.11
6	0.15	20	0.16
7	0.12	21	0.13
8	0.13	22	0.11
9	0.12	23	0.17
10	0.16	24	0.38
11	0.12	25	0.12
12	0.48	26	0.11
13	0.31	27	0.14
14	0.21		
Average			0.18 ms

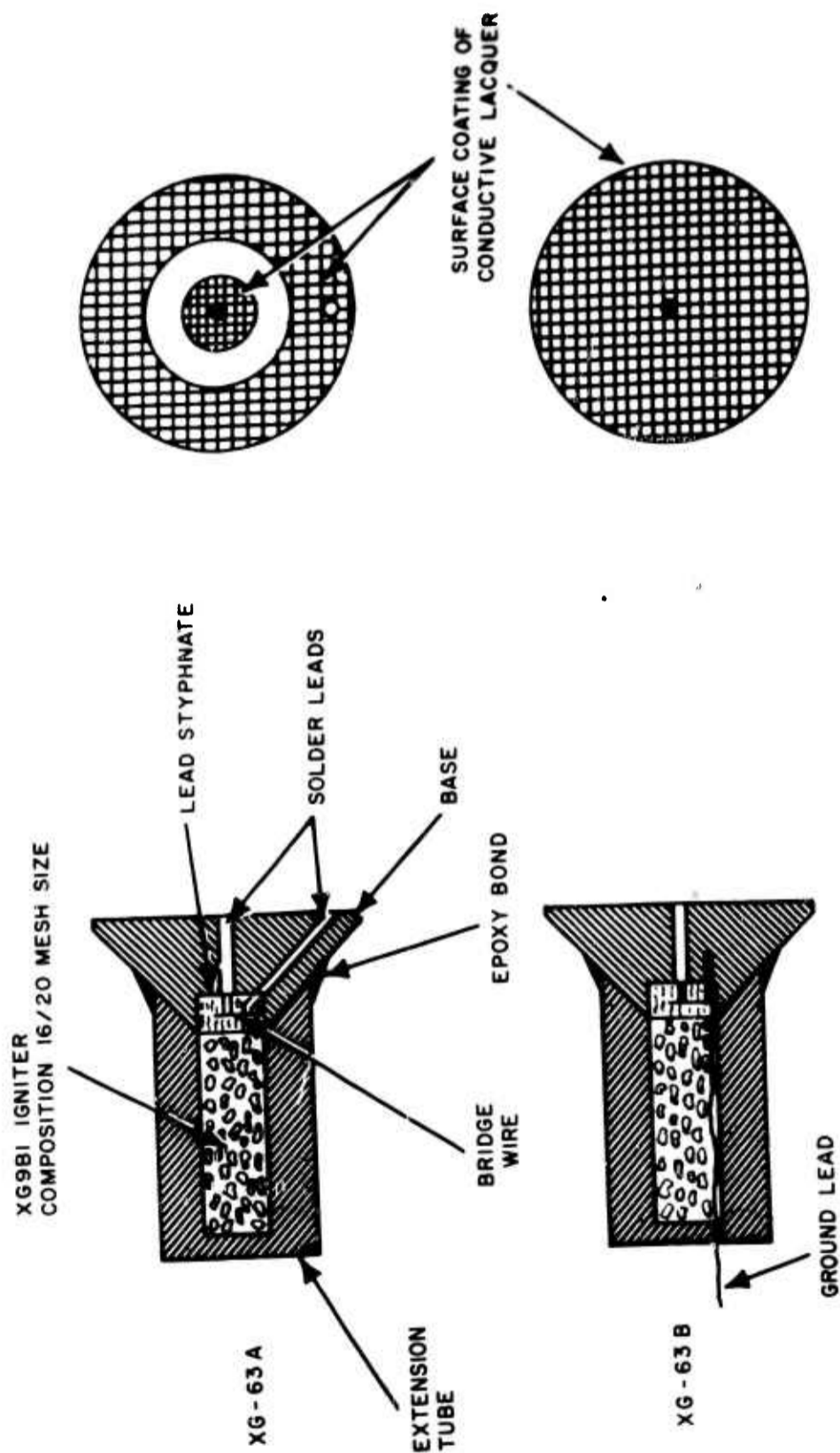


FIG. 1 COMPLETELY CONSUMABLE PRIMER

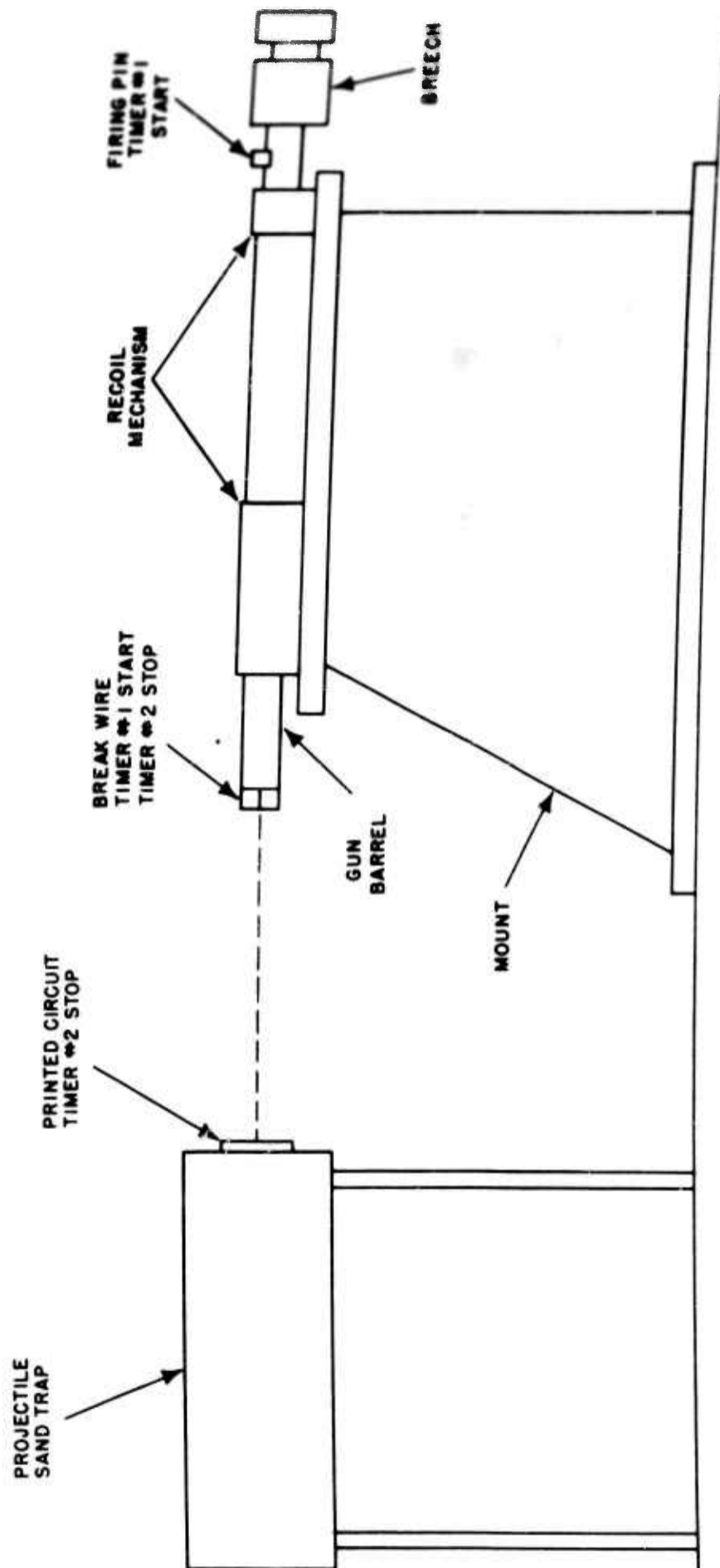


FIG. 2 SCHEMATIC OF TEST FIRING FACILITY

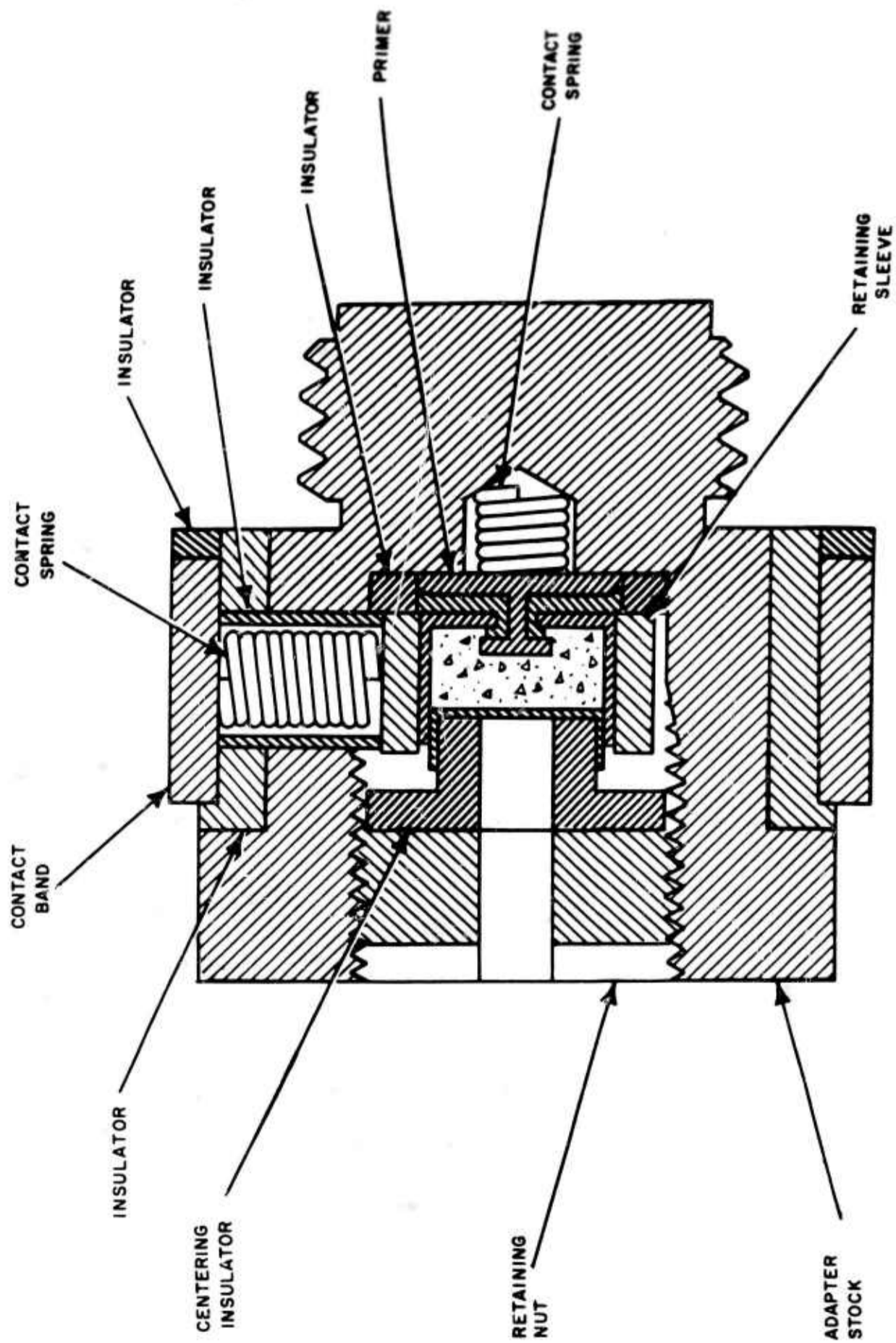


FIG. 3 PROJECTILE PRIMER

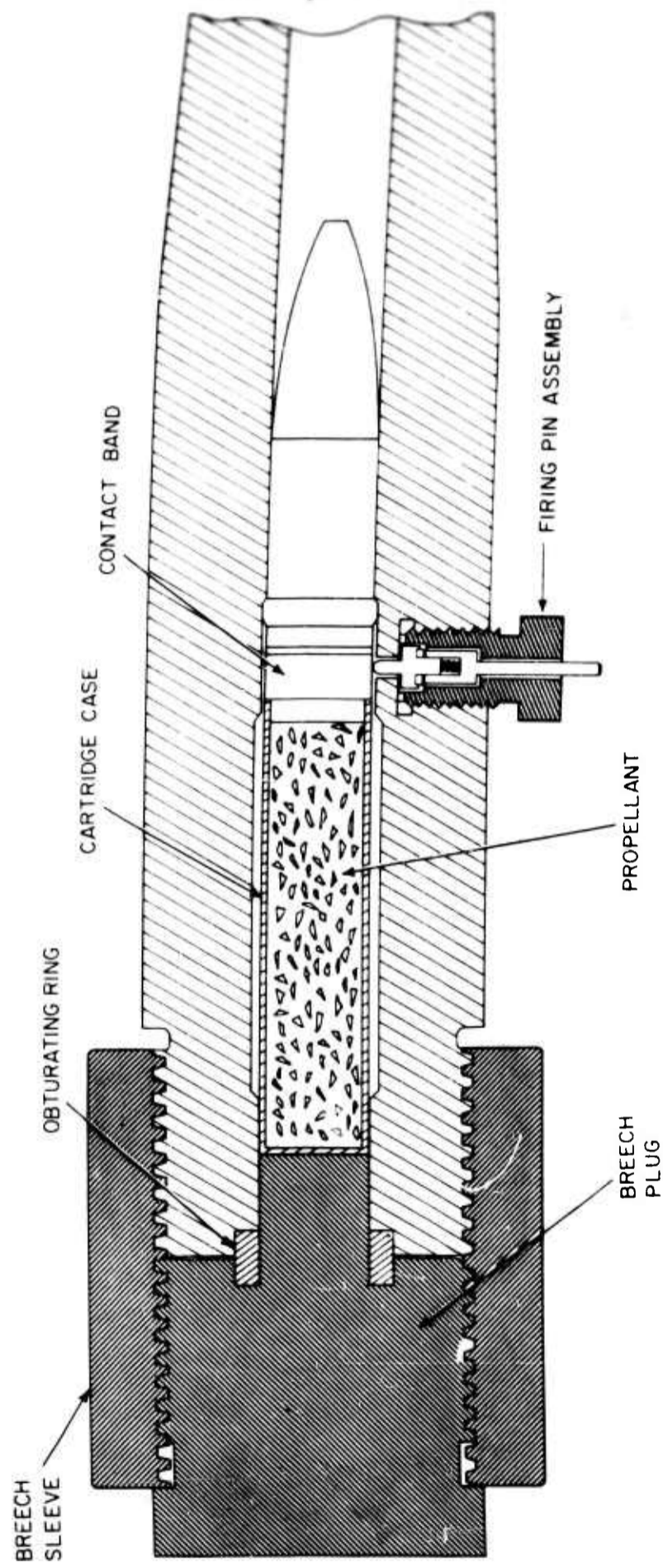


FIG. 4 GENERAL ARRANGEMENT OF CHAMBER
FOR FIRING PROJECTILE PRIMED ROUNDS

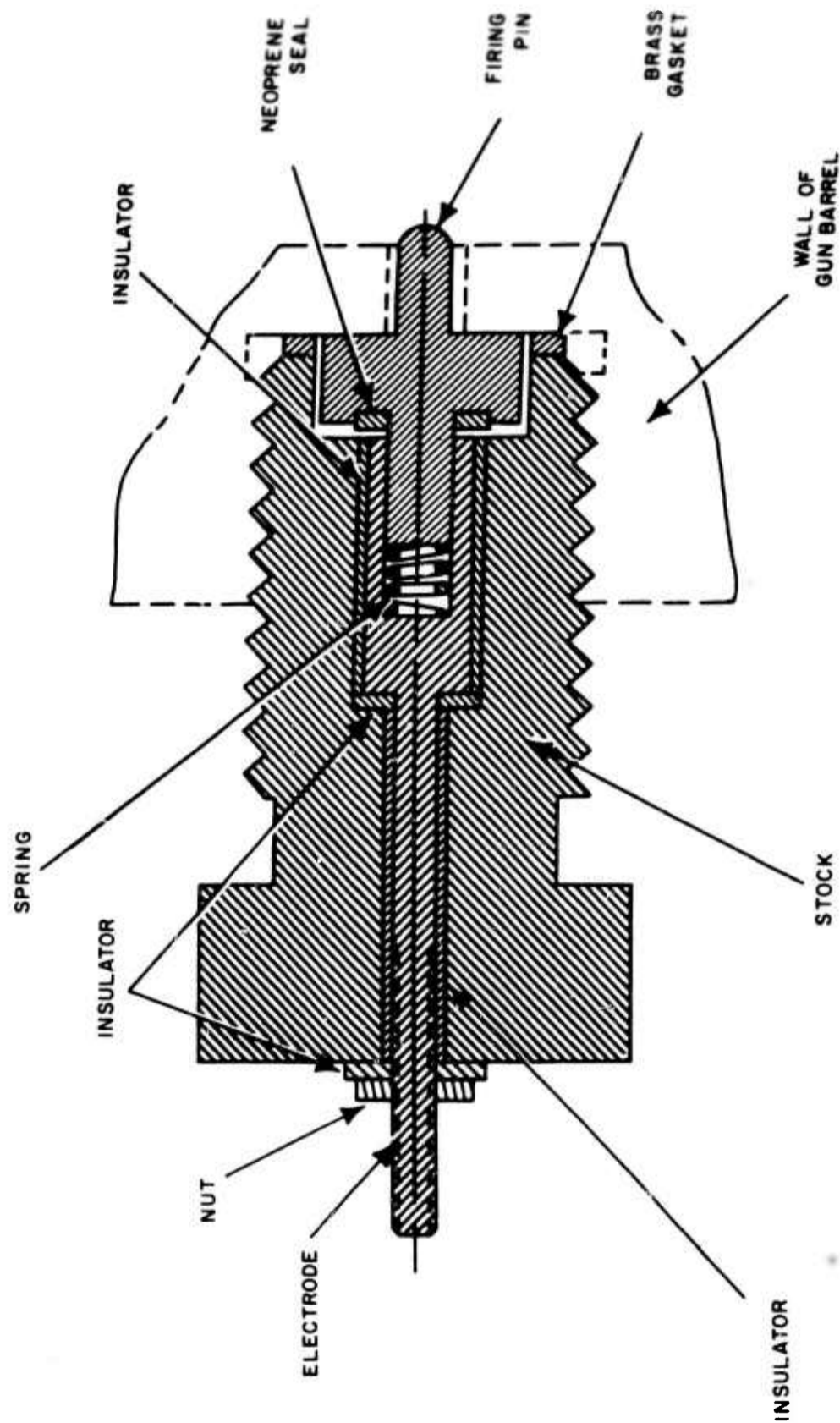


FIG. 5 GENERAL ARRANGEMENT OF SELF-OBTURATING FIRING PIN

KEY: A - HIGH FREQUENCY POWER SUPPLY
 C₁ - CAPACITOR BETWEEN BARREL RING AND BARREL
 L₁ - PARALLEL INDUCTANCE TO TUNE C₁ TO ANTIRESONANCE
 C₂ - CAPACITOR BETWEEN BARREL RING AND PROJECTILE CONTACT RING
 R₁ - PRIMER
 S₁ - FIRING SWITCH

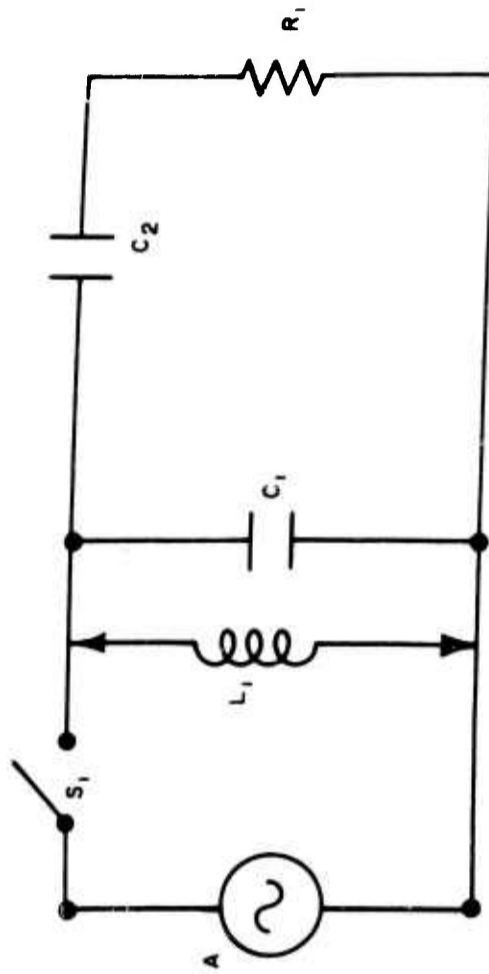


FIG. 6 CAPACITOR COUPLING INFLUENCE FIRING CIRCUIT

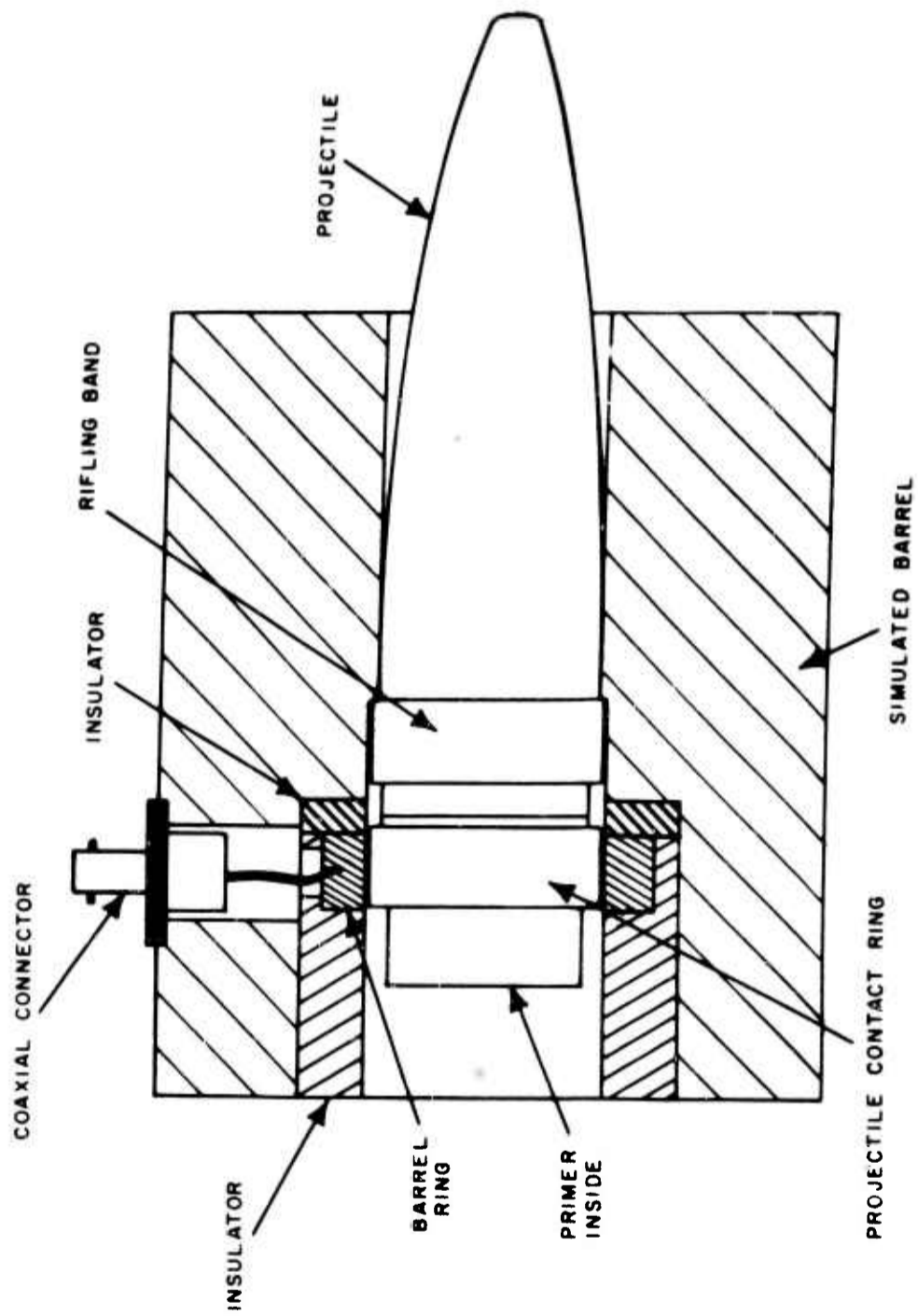


FIG.7 CAPACITOR COUPLING TEST FIRING FIXTURE

$$C_T = \frac{C_3 C_2}{C_3 + C_2}$$

$L_2 C_T = L_1 C_1$ (RESONANCE FREQUENCY = 0.5 MEGACYCLES)

C_2 = BAND-PROJECTILE CAPACITANCE

C_1 = BARREL CAPACITANCE

S = WESTERN ELECTRIC 276B RELAY

R = SERIES RESISTANCE TO PREVENT BACKFLOW OF CURRENT TO BATTERIES

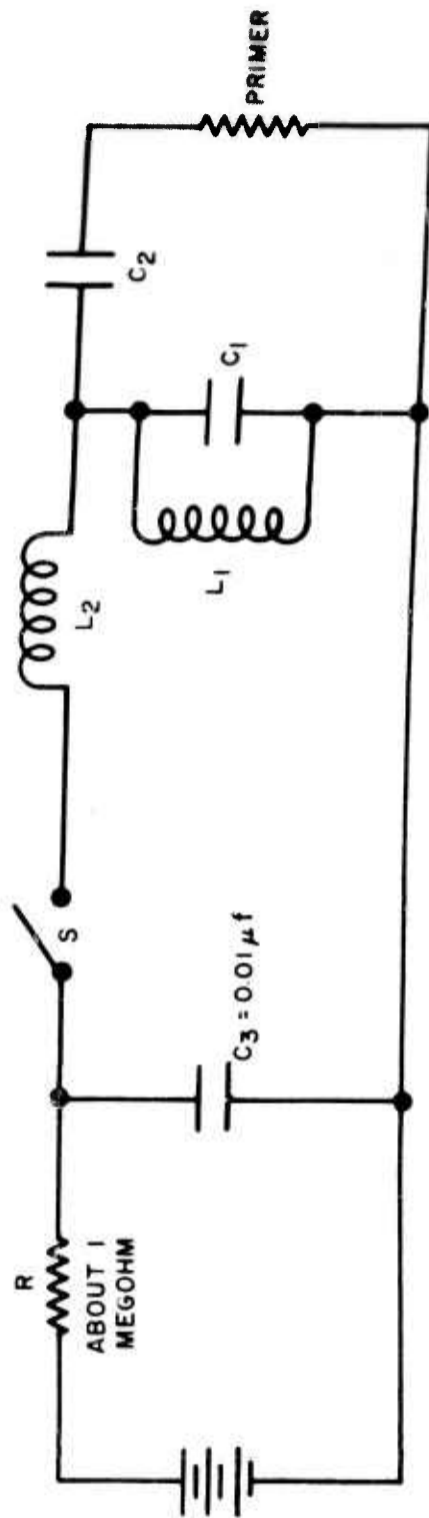


FIG. 8 CAPACITOR COUPLING INFLUENCE FIRING CIRCUIT USING
A CONDENSER DISCHARGE PULSER

Naval Ordnance Laboratory, White Oak, Md. (NAVORD report 4517)
AN IGNITION SYSTEM FOR CONSUMABLE CASE AMMUNITION, by Edwin F.
Abrams and others. 27 May 1957. 15p. Tabular. Project MOL-8a2a-
329. Project WD-182-816/44011/02040.

CONFIDENTIAL

Three methods of igniting consumable case ammunition were studied:
1. A primer fabricated from consumable material located in the normal
position at the rear of the cartridge case. 2. A primer located in
the case of the projectile contacted by a firing pin through the side
wall of the barrel. 3. A projectile primer fired through a separator
coupling which eliminates the need for a firing pin. Firing results
for all three methods are presented along with illustrations and methods
of fabrication.

1. Ammunition - Ignition
2. Ammunition, Consumable
3. Ignition systems
4. Primers, Electric - Firing
5. Title
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